CHAPTER 12 ATOMIC NUCLEUS

- ✓ 1896 Radioactivity discovered - Becquerel
- ✓ 1898 Radium / Polonium - Curies
- ✓ 1899 α / β are different - Rutherford
- ✓ 1902 transmutation - Rutherford & Soddy
- ✓ 1909 α "rays" are Helium nuclei - Rutherford & Royds
- ✓ 1911/12 nucleus of + charge ~ 10^{-15} m - Rutherford, Geiger, Marsden
- ✓ 1921 laboratory transmutation - Rutherford & Chadwick
- ✓ 1929 proton accelerator - Cockcroft & Walton
- ✓ 1931 Deuterium discovered - Urey
- ✓ 1932 neutron discovered - Chadwick
- ✓ 1933 artificial radioactivity - I. Curie & Joliot
- ✓ 1938 nuclear fission - Hahn & Strassmann
- ✓ 1942 controlled nuclear fission reactor - Fermi

Non-historical PROPERTIES

All nuclei consist of protons and neutrons

"protons" discovered and named by Rutherford in 1920/21

→ notation

Z. "Atomic Number" = # protons in the nucleus

N. "neutron number" = # neutrons

A. "mass number" = Z + N

symbol for nuclei:

$${}^{A}_{Z}X_{N}$$ --- often "Z" omitted.

So, Nitrogen: $^{14}N_7$

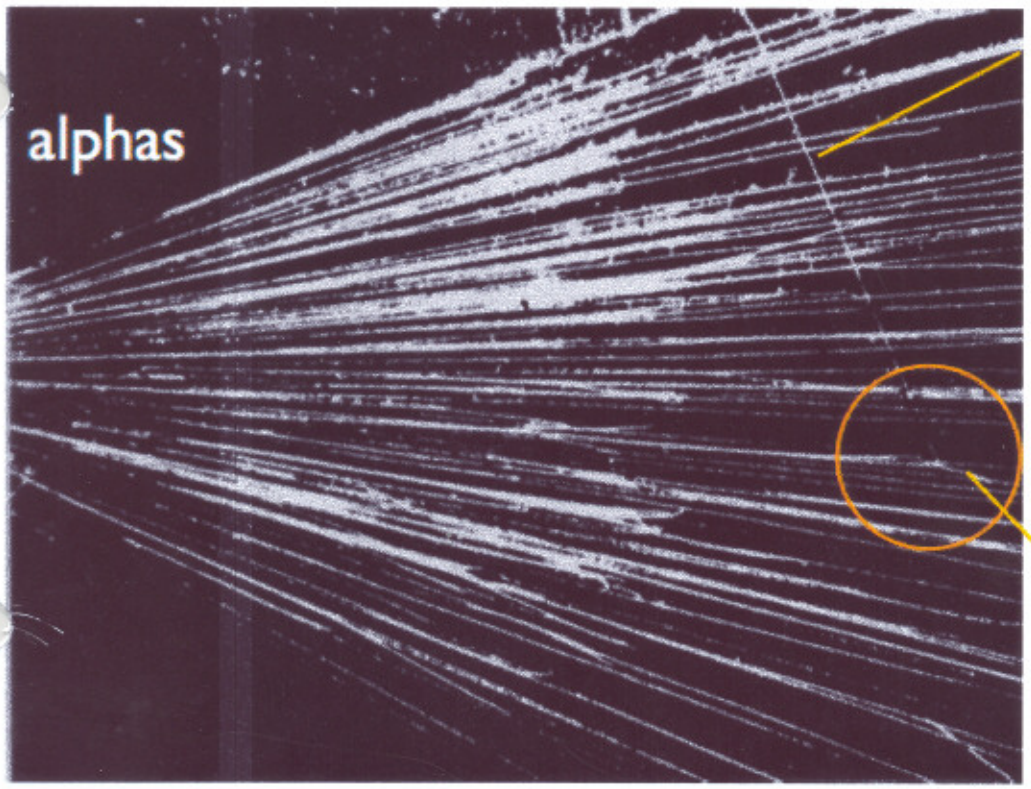
Oxygen: $^{17}O_8$

α: $^{4}\alpha_2$ or $^{4}He_2$

proton: $^{1}H_1$

& Rutherford's discovery experiment:

$$^{14}N_7 + {}^{4}\alpha_2 \rightarrow {}^{1}H_1 + {}^{17}O_8 \quad \text{or} \quad {}^{14}N_7(\alpha,p)^{17}O_8$$


alphas
proton
oxygen

"isotope" elements have different numbers of ~~protons~~ neutrons, but same # protons (... "element"!)

For example, natural abundances can vary.. take Carbon:

$^{11}_{6}C_5$ ^{11}C $^{11}C_5$ trace

$^{12}C_6$ – 98.6% of naturally occurring Carbon

$^{13}C_7$ – 1.1%

$^{14}C_8$ – trace

Discovery of Neutron... (predicted by Rutherford)

Bothe & Becker, 1930 found

something – penetrating
NOT ionizing ⇒ neutral
γ's ?

I. Curie & Frederic Joliot inserted a paraffin target

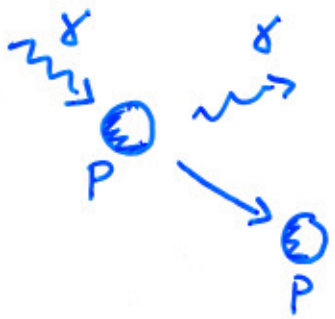
sometimes protons
KE = 5.3 MeV
they said "Compton"

Rutherford said... ~~"I beg to differ."~~

"I DON'T BELIEVE IT!"

Marie must not have taught Irene relativistic mechanics:

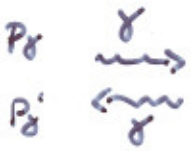
I.C & F.J. said



KE = 5.3 ~~Mev~~ MeV

try head-on collision: & elastic:

$$\gamma + p \rightarrow \gamma' + p'$$



$$p_\gamma' - p_\gamma = p_p$$

$$|p_p| = 2|p_\gamma|$$

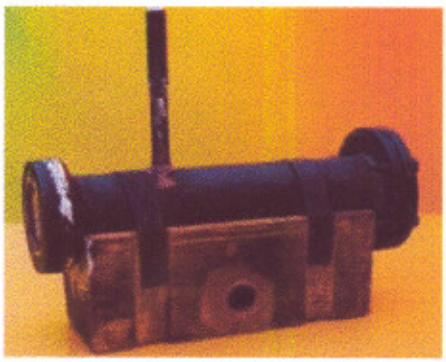
But

$$\sqrt{p_p^2 c^2 + m_p^2 c^4} = E_p = KE + m_p c^2$$

$$p_p^2 c^2 + \cancel{m_p^2 c^4} = KE^2 + 2KE \cdot m_p c^2 + \cancel{m_p^2 c^4}$$

$$p_p c = \sqrt{KE^2 + 2KE \cdot m_p c^2} = 99.9 \text{ MeV}$$

$\Rightarrow$ $p_\gamma c = 50$ MeV ... HUGE for γ-decay or α-scattered



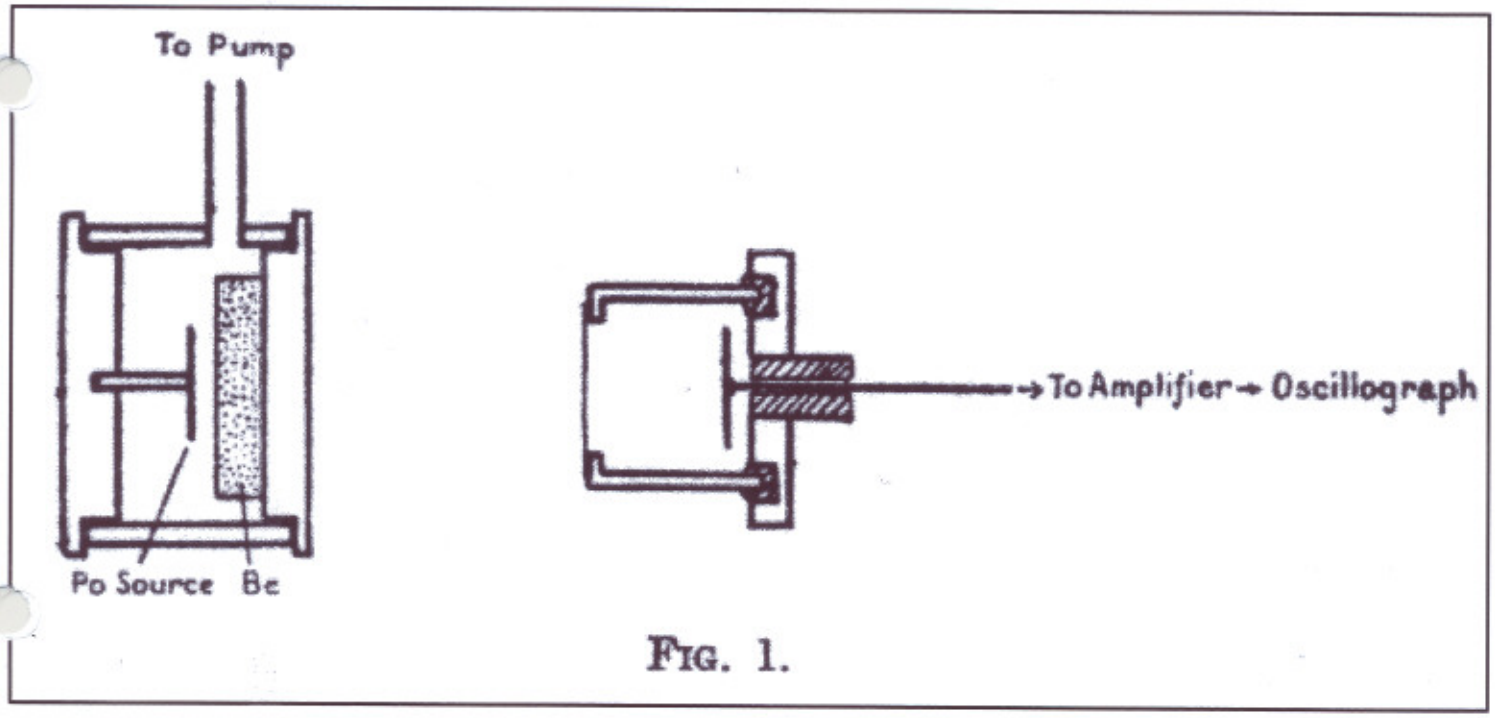


FIG. 1.

James Chadwick got the problem

Boron (N_2)

(know mass well)

He also used H_2 ---

$n + p \rightarrow p + n$

by assuming $m_? \simeq m_p$

→ velocity of n

→ mass of n.

found $m_n = 938 \pm 1.8$ MeV/c^2 – named it "neutron"

then, improved it to close to modern value $m_n = 939.57$ MeV/c^2

So, by 1932 -- nucleus contained both protons & neutrons.

Generically -- we call a "nucleon" either a proton or neutron

"A" is the number of nucleons